



## Numerical modelling of the transition from low to high confinement in magnetically confined plasma

Rasmussen, Jens Juul; Nielsen, Anders Henry; Madsen, Jens; Naulin, Volker; Xu, G. S.

*Publication date:*  
2015

*Document Version*  
Peer reviewed version

[Link back to DTU Orbit](#)

### *Citation (APA):*

Rasmussen, J. J., Nielsen, A. H., Madsen, J., Naulin, V., & Xu, G. S. (2015). *Numerical modelling of the transition from low to high confinement in magnetically confined plasma*. Abstract from 42nd European Physical Society Conference on Plasma Physics, Lisbon, Portugal.

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

## **Numerical modelling of the transition from low to high confinement in magnetically confined plasma**

J. Juul Rasmussen<sup>1</sup>, A.H. Nielsen<sup>1</sup>, J. Madsen<sup>1</sup>, V. Naulin<sup>1</sup>, and G.S. Xu<sup>2</sup>

<sup>1</sup>*PPFE, Dept. of Physics, Technical University of Denmark, Kgs. Lyngby, Denmark*

<sup>2</sup>*Institute of Plasma Physics, Chinese Academy of Sciences, Hefei, People's Republic of China*

An outstanding issue in magnetic fusion research is the understanding of the transition from the Low (L-mode) to the High (H-mode) confinement regime. Although the H-mode is routinely achieved in a multitude of magnetic confinement devices, since the first observation more than 30 years ago, the transition still lacks full theoretical explanation and predictive modelling. This is a high priority topic since ITER will rely on operation in H-mode to achieve the goal of ignition.

We present numerical modelling of the L-H transition based on the first-principle fluid model HESEL (Hot Edge-Sol-Electrostatic). The model is a four-field drift-fluid model including generalized vorticity, density, electron and ion pressure equations and using the Braginskii closure for collisions. The model is solved on a 2D domain at the out-board mid-plane of a Tokamak including both open and closed field lines. The parallel dynamics is parameterized in the open field line region – the scrape off layer - accounting consistently for the parallel losses.

The results, obtained for parameters typical for medium sized Tokamaks (MST), reveal different types of L-H-like transitions in response to ramping up the input power. For a fast rising input power we obtain an abrupt transition, and for a slow rising power we obtain the L-I-H transition with the intermediate I-phase displaying limit cycle oscillations (LCO). The L-I-H transition has been observed in several devices and investigated in great detail by applying advanced imaging systems. Direct comparisons with recent experimental findings in the Experimental Advanced Superconducting Tokamak – EAST [2] have revealed close agreement in a multitude of observables between simulations and experiment for the evolution of the L-I-H transition, specifically including the phase relations during the triggering events. Additionally, the model reproduces the experimentally determined L-H transition power threshold and the scaling that the ion power threshold increases with increasing particle density [3]. Presently the investigations are extended for comparisons with other MST devices, e.g., ASDEX Upgrade.

The simplified model presented here, lacking, e.g., toroidal geometry effects, appears to contain the necessary and essential ingredients for revealing the transition behaviors, but is still not a fully predictive model. The results presented form an essential step connecting zero- and one-dimensional heuristic transition models with a predictive model. Thus, the results hold promises for developing a full predictive modelling of the L-H transition, which is an essential step in understanding and optimizing fusion devices.

[1] A.H. Nielsen et al., (2014), <http://arxiv.org/abs/1409.3186>

[2] G.S. Xu et al., Nuclear Fusion **54** 013007. (2014)

[3] F. Ryter et al., Nuclear Fusion **54**, 083003 (2014)